Chapter 14
Education Policy and Behavioral Change in Science Learning—An Empirical Analysis Based on Japanese Data

Kazuo Nishimura, Tadashi Yagi, and Dai Miyamoto

Abstract The study of science subjects in school education is important for the advancement of science and technology. However, it is true that many students avoid science and mathematics. The significance of examining strategies for raising interest in science subjects and elevating learning benefits is considerable. We asked researchers and engineers who are applying science skills in work about their experience of education in science subjects, and their study of science subjects from elementary school through university. We then examined how their experience and study related to later capabilities as researchers and engineers. Based on data obtained, we analyzed the influence of education policy on science study behavior, as a factor in raising interest in science subjects and willingness to study science. Our results confirmed the importance that "associating science learning with daily life" has in exerting a positive influence on science learning behavior and on raising specialized skills. This is additional to the generally accepted concept of stimulating interest in science through class content at an early stage, in the early years of elementary school education. Meanwhile, a decline in the ratio of students who like science, an increase in students' perceptions that they are weak in science, a decline in the sense of strength in science, and an ongoing distancing from science have been highlighted as consequences of the "Relaxed Education" policy.

Keywords Education policy · Science learning · Behavioral change · Like science · Dislike science · Specialized skills

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1 Introduction

Science education in Japan has undergone significant changes over the past 30 years. In the university admission exams for the 2008 school year, the total number of applicants for engineering departments was 245,000. This represented a 37% decline compared with the 1992 school year. During the 1970s, the ratio of students studying physics in senior high school was in the 80–90% range. After the 1982 revision of curriculum guidelines, the ratio dropped sharply to the 30% range. It is reported to have fallen below 20% in 2008. In line with the so-called "Relaxed Education" policy, class hours and curriculum content were reduced three times, first in 1978, and then in 1989 and 1998. Education in science subjects deteriorated as a result.

This decline in the level of education in science subjects is sapping Japan's technological strength (Nishimura et al. 2018). Examining trends since the 1990s of patent application numbers by the four countries with the highest totals, the number of applications by Japanese people peaked in 2005 at about 530,000. By 2014, the total had declined by more than 10% to about 470,000. This trend is not seen with other countries (see Fig. 1). Furthermore, until 2011, Japan had the world's highest total patent applications. Today, Japan has fallen to third place, behind China and the US. The gap between Japan and South Korea is also shrinking. From the perspective of total patent applications, Japan's R&D strength can be confirmed as being on a downward trend, both relatively and absolutely. Additionally, processing of data obtained from the Thomson Reuters Web of Science (WoS) abstract database showed that, until the early half of the 2000s, Japanese people were in the top level internationally for number of engineering-related publications. However, as with number

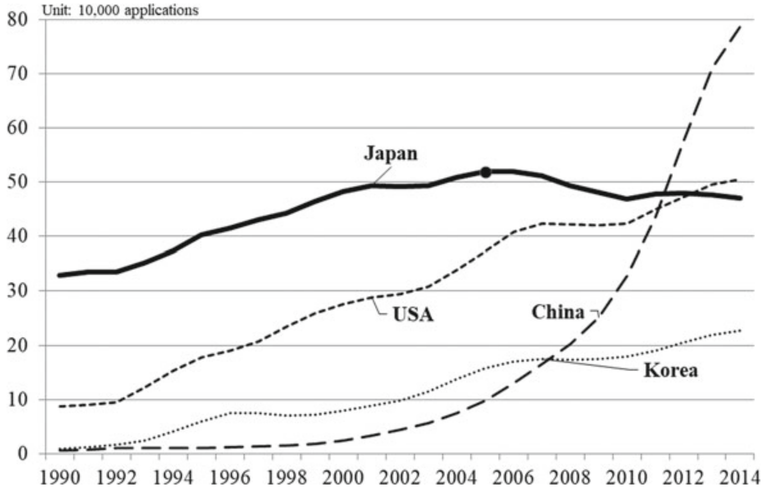

Fig. 1 Trends of total patent applications by applicants' countries of origin (three-year moving average) *Source* Indicator 1: Total patent applications (direct and PCT national phase entries) by applicants' origin, WIPO statistics database

of patent applications, the number of such publications by Japanese has continued to fall, relatively and absolutely, since about 2005. The decline of Japan's R&D strength therefore cannot be considered just a temporary phenomenon.

Globally, demand for and supply of R&D personnel have become strained in recent years. In particular, R&D personnel needed by industry for advanced technology are increasingly in short supply. Furthermore, obtaining talented R&D personnel from outside Japan is difficult. Evaluation of the effects that education policy has had on science learning behavior, and analysis of how education policy and teaching methods can modify science learning behavior, are vital steps in examining cultivation of talented R&D personnel for Japan in the future.

This chapter focuses on the results of questionnaire surveys we conducted in relation to science subject learning behavior, targetting Japanese engineers and people engaged in science-related research. Based on the data accumulated, we clarify characteristics of science study relevant to raising the capability of engineers and researchers. From there, we clarify what could modify willingness to study science. Additionally, analysis of the relationship of capability as researchers or engineers, with science education and study undertaken from elementary school through university, shows the effects that education policy changes have had on study behavior concerning science subjects.

Breakwell and Beardsell (1992) examined changes in study behavior concerning science and maths subjects, stemming from the influences of gender and social intimates including parents. Their study focused on children in the UK, between the ages of 11 and 14 years. Osborne et al. (2003) presented and analyzed the effects of the following seven issues as factors influencing willingness to study: (1) motivation to learn, (2) self-efficacy in science learning, (3) anxiety regarding science, (4) awareness of science, (5) science teacher perspectives on science study, (6) participation in extracurricular science activities, and (7) interest in a science-related occupation. Tytler (2014) surveyed existing research on how science education can be conducted to raise willingness to study, and learning benefits.

Eccles (1983) asserted that academic achievement of students is determined by a balance of two elements—the value of goals that students wish to achieve, and expectations toward potential for achievement. Additionally, Wan (2019) studied ten-year-old children in Hong Kong to determine effects of science learning motivation and self-efficacy on the willingness to learn science.

Referring to existing research as noted above, for this chapter we designed questionnaire surveys that would allow evaluation of factors stimulating behavior modification in science learning. The surveys targeted Japanese engineers and science researchers. Analyzing the data obtained, we examined factors that raise effectiveness of science education.

Section 2, below, explains the survey method and gives an overview of the data. Section 3 examines the education policy changes in Japan and analyzed the effects on formation of science capability. Section 4 clarifies factors drawing out interest in science considers. Section 5 examines the factors determining degree of strength in science in senior high school. Section 6 clarifies factors determining specialized skills of engineers and researchers.

2 Survey Method and Data Overview

The first batch of survey data was obtained in March 2016 through the research service (NTTCom Research) of NTTCom Online Marketing Solutions Corporation. The survey was titled “Questionnaire Survey on Perceptions in Engineering and Research Occupations” (1st Survey) and conducted via the internet. It focused on individuals who were working in engineering and research, and generally thought of as R&D personnel. Of the 153,272 questionnaires distributed, 17,440 preliminary survey responses were received. The number of full survey responses was 5241, giving a recovery ratio of 3.4%. After screening for engineering and research occupations, the final number of valid responses was 4,129. A follow-up survey was then implemented in March 2017, targetting respondents to the 1st Survey “Follow-up Questionnaire Survey on Perceptions in Engineering and Research Occupations” (2nd Survey). The survey content consisted of questions concerned mainly with likes and dislikes relating to sciences. The follow-through sample size for the 1st Survey and 2nd Survey was 2,065 respondents. An additional survey of respondents to the 2nd Survey was conducted in July 2017 “Questionnaire Survey on Study of Science in University” (3rd Survey). The follow-through sample size from the 1st Survey to the 3rd Survey was 1152 persons.

The data obtained had the following traits. Gender ratios were male 92.1% and female 7.9%, showing an overwhelming number of males. The academic record of university graduation or higher was 75.4%, and average age was 33.22 years (standard deviation 9.20 years). Of respondents who completed university undergraduate study or higher, 78.9% majored in science courses; 19.1% hailed from liberal arts courses; and 2.0% undertook integrated science/liberal arts courses. Average annual pre-tax income for all samples was 6,697,519 yen, with standard deviation of 3,600,000 yen.

3 Education Policy Changes and Effects on Formation of Science Capability

In Japan’s education policies, curriculum guidelines have been amended according to specific themes once almost every ten years, between 1961 and the present day. When the theme changed, so did the curriculum guidelines. As indicated in Table 1, the guidelines have therefore changed substantially, compared with education in the 1950s. Considering arithmetic and mathematics, for example, education from 1951 to 1960 was based on learning of discrete study units. This is called “Pre-relaxed Education I”. From 1961, focus shifted to perceptions of goals for arithmetic/mathematics, and the scholastic achievement that should be attained for those goals acquired importance. Arithmetic/mathematics education in the education period 1961–1970 focused on “Systematic Learning” during the “Pre-relaxed Education II” period. Over the period 1971–1979, the emphasis turned to “Education Modernization” during the “Pre-relaxed Education III” period, and curriculum guidelines were steadily revised

Table 1 Age group categories: curriculum guidelines during elementary school

	Respondent age groups at time of 1st Survey
Pre-relaxed Education I (1951–1960)	62 years or older
Pre-relaxed Education II (1961–1970)	52–61 years
Pre-relaxed Education III (1971–1979)	43–51 years
Relaxed Education I (1980–1991)	31–42 years
Relaxed Education II (From 1992–)	30 years or younger

to reflect the development of society. The era from 1980 to 1991 was given to "Relaxed Education". Content was gradually reduced in accordance with curriculum guidelines, to reduce study hours for children. Since 1992, curriculum guidelines have centered on cultivating ability to think, under the banner of "New Concepts of Academic Ability/Power of Life" during "Relaxed Education II".

We surveyed engineers and science-oriented researchers who received elementary school education in one of the curriculum guideline eras shown above. Respondents were also asked whether they liked or disliked science subjects during their time as university undergraduates. As the survey respondents were engineers and science researchers, it might be assumed there is a fundamental liking for science subjects. However, the survey results showed 72.3% selected "Liked", and 27.7% answered "Did not like". Of the respondents who declared they liked science subjects, 33.4% said they acquired a liking for science during the early years of elementary school. Meanwhile, 23.0% stated they acquired a liking for science during the later years of elementary school, 10.8% during junior high school, and only 5.1% during senior high school or later. In contrast, of the respondents who did not like science, 30.8% said their dislike emerged in junior high school, while 29.4% pointed to senior high school.

Figure 2 shows the ratios of respondents who stated they liked science subjects in university, according to curriculum guideline era and age group. Among engineers and researchers who were educated during the "Pre-relaxed Education III" era, 78% declared they enjoyed science subjects during university. In contrast, the ratios of liking for science subjects fell to 73% for respondents from the "Relaxed Education I" age group, and to 64% for the "Relaxed Education II" age group.

To obtain detailed analysis of the characteristics of science learning, questions in the surveys used for this chapter covered 56 items relating to science study from elementary school through senior high school. The Appendix shows the outcome of a search-type factor analysis of the survey results. The methods used for factor extraction were principal component analysis, and rotation by the Equamax method with Kaiser normalization. The variables extracted through factor analysis were: (1) enthusiasm toward studying science from junior high school onward, (2) a sense

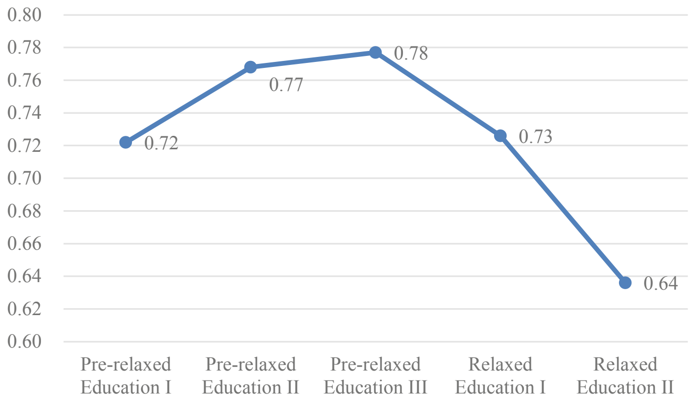

Fig. 2 Ratios of liking for science subjects as undergraduates, according to curriculum guideline era

of strength in science from junior high onward, (3) a sense of strength in science during elementary school, (4) studying science with friends, (5) association of science learning with daily life, (6) affinity for the content of science studies, (7) enthusiasm toward science learning during elementary school, (8) patience in learning science during elementary school, and (9) a sense of weakness in science from elementary school through university. The correlation coefficient between these samples was confirmed as 0 by orthogonalization.

Of the nine variables extracted from results of factor analysis, we examine two variables according to curriculum guideline era and age group: (2) a sense of strength in science from junior high onward, and (9) a sense of weakness in science from elementary school through university. Figure 3 plots the sense of strength and sense of weakness in science in terms of curriculum guidelines by era and age group. As shown, since the introduction of "Relaxed Education", the sense of weakness in science has climbed sharply, whereas the sense of strength in science capability has seen a major decline. These results can be interpreted as showing that the "Relaxed Education" policy caused a major decline in science capability.

4 Education Periods in Which "Like Science" and "Dislike Science" Emerged, and the Causes

The previous section showed how education policy changes led to changes in the ratios of "like science" and, correspondingly, in the sense of strength or weakness in science. In this section, we analyze for triggers leading to a liking for science, and the education periods in which they occurred. To narrow down the triggers for acquiring a liking for science, the surveys offered the following choices: "Class experiments", "Class talk was interesting", "Understood class talk", "Books",

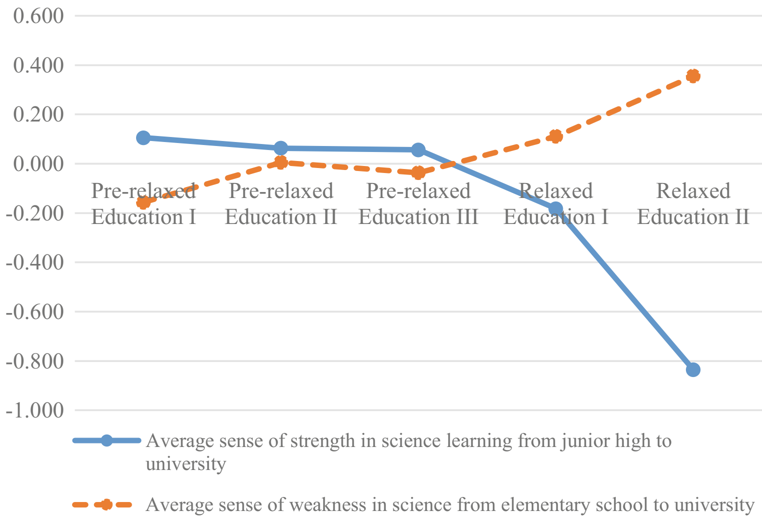

Fig. 3 Science capability by curriculum guideline era/age group

"Extracurricular experiments, in clubs, etc.", "Events such as talks by scientists and researchers", "Astronomical observations", "Television programs", "Family influences, incl. parents' occupations" and "Other".

Figure 4 shows the education periods in which respondents acquired a liking for science and the triggers in each period. In elementary school, the most common trigger for attaining a liking for science was "Class experiments". This trigger had a high ratio in all education periods.

The second and third most important triggers for acquiring a liking for science were "Class talk was interesting" and "Understood class talk". In particular, we need to note the rising ratio of "Understood class talk", moving from junior high school to senior high school. The influence of "Books" was also large, and the figure shows classroom instruction and books are triggers for acquiring a liking for science.

The surveys also asked about why respondents came to dislike science. The choices offered were: "Classes were difficult and I could not understand", "Classes were uninteresting", "Disliked insects and other creatures", "Experiments were uninteresting", and "Experiments were difficult and I could not understand". Figure 5 shows the education periods in which respondents turned away from science, and the triggers. The most common trigger in each education period was "Classes were difficult and I could not understand", followed by "Classes were uninteresting". This underlines the importance of the nature of classroom instruction.

From Figs. 4 and 5, we understand classroom instruction in schools has a considerable influence on whether students acquire or lose interest in learning science.

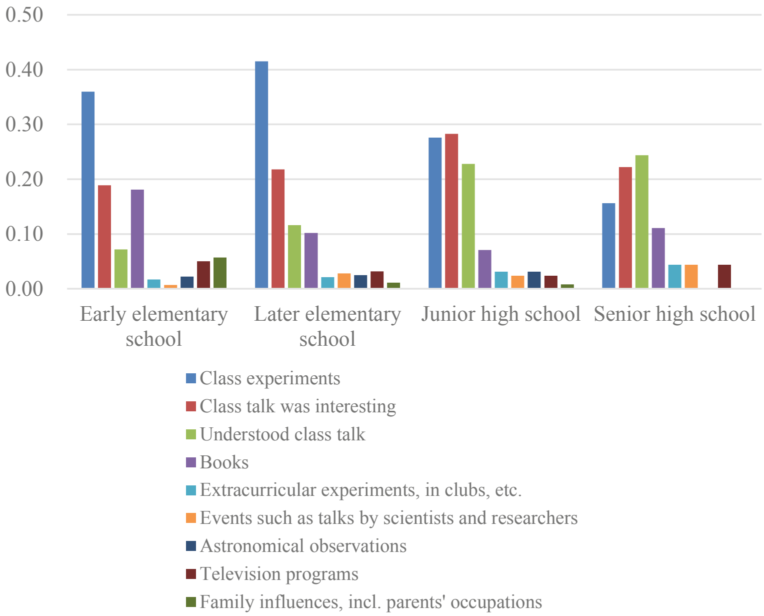

Fig. 4 Education period and reasons for acquiring a liking for science

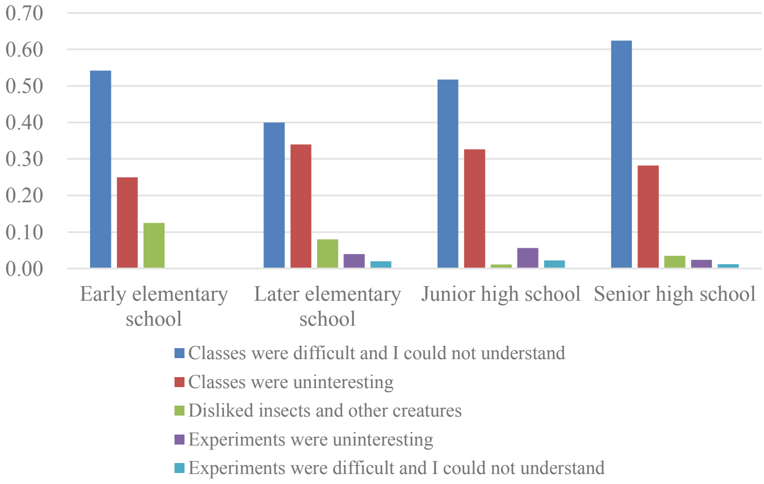

Fig. 5 Education period and reasons for turning away from science

5 Factors that Determine the Degree of Strength in Physics in Senior High School

Additionally, we conducted multivariate regression analysis of factors determining degree of strength in physics in senior high school. These included responses to the question "Did you have any experience during classroom instruction or experiments in science that inspired awe or wonder (Inspiring class experience)?", and reasons for acquiring a liking for science or turning away from science as discussed in Sect. 4, in addition to factors extracted through factor analysis.

Figure 6 is based on results of multivariate regression analysis. Bar heights represent standardized coefficient values of elements with statistically significant influence on degree of strength at the 5% significance level. Comparison of standardized coefficient values allows comparison of the strength of influence of each factor. When the value of a factor is negative, it has a negative effect on degree of strength.

The following variables have a strong, positive influence on degree of strength in physics in senior high school: "Began to like science in early elementary school (Early elementary school dummy variable)", "Understood class instruction", "Inspiring experience in science", "Associated science learning with daily life", "Class talk was interesting" and "Had affinity for science study".

"Class experiments" should be noted among factors that did not influence degree of strength. Theoretical understanding of the content of experiments is thought to be important for linking "Class experiments" to formation of science capability. Learning to like science in the early years of elementary school has a positive influence on degree of strength.

It is likely that having interest in science and undertaking appropriate study in the early years of elementary school will raise level of understanding of science in class

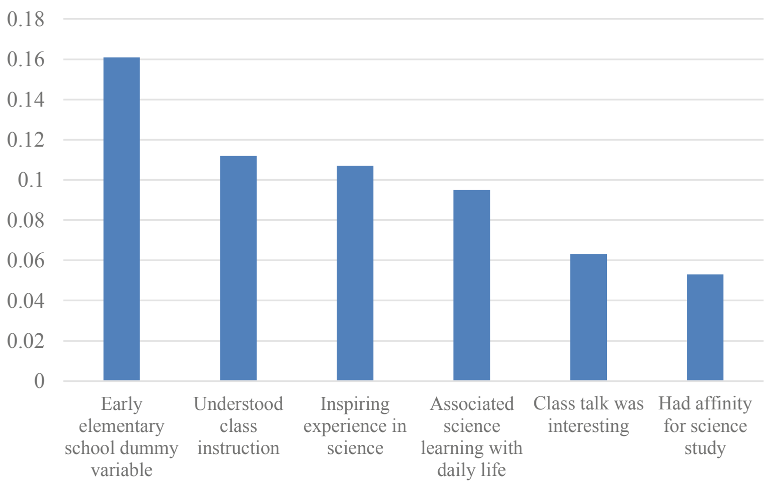

Fig. 6 Factors that determine degree of strength in physics in senior high school

instruction, and subsequently the longer-term potential for formation of capability as an engineer or science researcher. Furthermore, associating science learning with daily life should result in more than simply a higher degree of strength in physics. Crucially, comprehension of compound relationships of individual scientific truths in real life is also shown as having a strong influence on formation of capability as an engineer/researcher.

6 Factors that Determine Specialized Skills of Engineers and Researchers

In this section, we analyze science learning characteristics that influence ability to accomplish activities as engineers and researchers. One survey question asked, "Do you feel you have occupational skill that would give you recognition outside the company as a specialist in your field of endeavor?" Response choices were on six levels: (1) no, (2) not much, (3) closer to no than yes, (4) closer to yes than no, (5) a little, and (6) yes. The responses to this question are interpreted as "Confidence in specialized skills".

Additionally, we examined the number of patent applications, a number that might be considered representative of specialized skills. However, many survey respondents were in occupation types or positions unrelated to patent applications, and the ratio of respondents who stated they had lodged at least one patent application was not high, at just 28.2%. Therefore, we did not use number of patent applications as a variable representing specialized skills. Even so, regarding respondents who stated they had lodged at least one patent application, regression of number of patent applications on confidence in specialized skills showed statistical significance at significance level of up to 1%, and consistency of confidence in specialized skills and number of patent applications. Ultimately, we used "Confidence in specialized skills" as a proxy variable for measuring specialized skills. This is referred to as "specialized skills", below.

Using these factors and degree of strength in physics and chemistry in senior high school, we analyzed the effect of science learning experiences on specialized skills. In Fig. 7, from characteristics of science learning in elementary, junior high, and senior high school we extracted only elements having statistically significant influence on specialized skills at the 5% significance level. Comparison of standardized coefficient values allowed a comparison of strength of influence of individual factors.

As shown by Fig. 7, of factors explaining current specialized skills, (1) degree of strength in physics in senior high school, (2) enthusiasm toward learning science from junior high school onward, and (3) association of science learning with daily life were statistically significant at the 5% significance level and imparted a positive influence. Degree of strength in chemistry was not statistically significant as a factor for explaining current specialized skills. Whereas degree of strength in physics in senior high school had a strong influence on specialized skills, degree of strength in

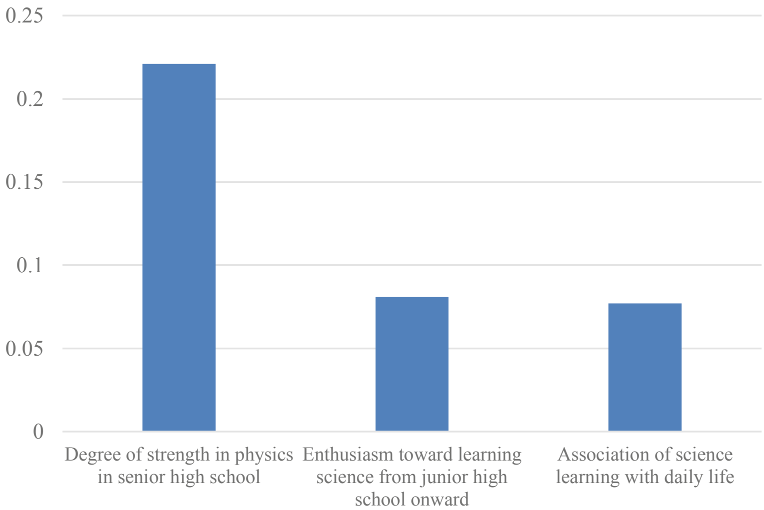

Fig. 7 Characteristics of science study in elementary/junior high/senior high schools, and specialized skills

chemistry in senior high school had no influence. This suggests, in contrast to study of chemistry, the study of physics contributes strongly to formation of fundamental capability.

The analyses above clarified factors behind science capability in elementary/junior high/senior high schools, and formation of specialized skills as engineers and scientists. An important point common throughout is that modification of science learning behavior is triggered by raising interest in science as part of daily life, beginning with the early years of elementary school education. This then links to formation of capability in science and formation of specialized skills as engineers and scientists. Revision of the state of science education from the early years of elementary school onward, and provision of an environment that can continue to stimulate interest in science, can be considered vital for cultivating a liking for science in children.

7 Conclusion

In this chapter, we analyzed connections between learning behavior in schools and formation of specialized skills, and factors influencing modification of such learning behavior, based on surveys of researchers and engineers. We then analyzed changes emerging in science capabilities of engineers and researchers, resulting from revisions applied to education policy. The findings obtained are as follows.

First, we showed that the "Relaxed Education" policy caused a major decline in science capability. Shortened class instruction hours in science subjects due to the policy led to a decline in children's interest in science, and a decline in the ratio of children who are strong in science. These results emphasize the importance of education policy on science ability formation.

Next, factors raising the important degree of strength in physics are: "Learning to like science at an early stage, in the early years of elementary school", "Class instruction is understood/interesting", "Inspiring experiences in science", "Associating science learning with daily life", and "Acquiring an affinity for learning science". Furthermore, in addition to raising degree of strength in physics, associating science learning with daily life enhances skills as engineers and researchers. It is interesting to note that the degree of strength in physics in senior high school has a strong influence on specialized skills of R&D personnel. In contrast, the degree of strength in chemistry does not have any effect.

The results of this research suggest the importance of stimulating interest in science at an early stage and of associating science learning with daily life, to raise science capability. Further research is needed to determine methods that would be effective for stimulating interest in science at an early stage of school education.

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Appendix

Results of factor analysis of responses to surveys on perceptions relating to science (correlation coefficients between questionnaires and factors).

	Enthusiasm toward study of science from junior high	Sense of strength in science from junior high	Sense of strength in science in elementary school	Studied science with friends	Associated science learning with daily life	Affinity for content of science learning	Enthusiasm toward study of science in elementary school	Patience in learning science in elementary school	Sense of weakness in science
18. (Junior high to university graduation) Recalled and reviewed important matters repeatedly when studying for tests	*0.732*	0.185	0.002	0.157	0.079	0.092	0.157	0.279	-0.047
19. (Junior high to university graduation) Summarized key points of various materials learned, to further understanding	*0.731*	0.139	0.02	0.198	0.103	0.105	0.313	0.137	-0.065
15. (Junior high to university graduation) Reorganized notes when studying, for better recall of material learned	*0.694*	0.057	0.033	0.218	0.019	0.071	0.404	0.093	0.011
16. (Junior high to university graduation) Worked individually on exercises not included in homework	*0.668*	0.199	0.097	0.143	0.17	0.019	0.22	-0.005	-0.13
17. (Junior high to university graduation) Completed study tasks even if the material being studied was boring and uninteresting	*0.627*	0.213	0.034	0.109	0.063	0.07	0.125	0.307	-0.067
20. (Junior high to university graduation) Applied material learned earlier when studying new topics	*0.603*	0.296	0.09	0.092	0.277	0.135	0.128	0.212	-0.217
13. (Junior high to university graduation) When studying, I would put important but difficult words into my own words	*0.593*	0.191	0.049	0.177	0.134	0.011	0.223	0.286	0.002
14. (Junior high to university graduation) Always tried to make sense of what the teacher was saying, even if I did not understand at the time	*0.584*	0.152	0.017	0.114	0.142	0.09	0.009	0.459	-0.012

12. (Junior high to university graduation) When doing homework, I tried to recall what was taught in class, to thoroughly answer problems	*0.574*	0.156	0.071	0.119	0.085	0.088	0.028	0.558	-0.053
11. (Junior high to university graduation) Compiled hints from class instruction, books, etc., when studying for tests	*0.513*	0.146	0.118	0.044	0.116	0.135	-0.089	0.501	-0.13
8. (Junior high to university graduation) I believe I achieved good academic results in science study	0.167	*0.806*	0.307	0.072	0.119	0.205	0.026	0.008	-0.234
7. (Junior high to university graduation) I believed I was strong in science studies	0.145	*0.804*	0.351	0.063	0.139	0.206	0.038	0.018	-0.213
6. (Junior high to university graduation) I had confidence in ability to learn science	0.162	*0.799*	0.363	0.057	0.163	0.204	0.022	0.016	-0.215
5. (Junior high to university graduation) I believe I studied science thoroughly	0.186	*0.766*	0.395	0.049	0.138	0.214	0.021	0.032	-0.183
2. (Elementary school) I had confidence in ability to learn science	0.019	0.243	*0.836*	0.032	0.147	0.249	0.109	0.139	-0.19
1. (Elementary school) I believe I studied science thoroughly	0.034	0.224	*0.832*	0.034	0.133	0.239	0.113	0.162	-0.162
4. (Elementary school) I believe I achieved good academic results in science study	0.025	0.272	*0.813*	0.028	0.127	0.264	0.08	0.116	-0.21
3. (Elementary school) I believed I was strong in science studies	-0.015	0.277	*0.808*	0.035	0.138	0.257	0.098	0.109	-0.216
15. (Junior high to university graduation) I studied science together with friends	0.199	0.079	0.027	*0.85*	0.133	0.008	0.035	0.113	0.005
14. (Junior high to university graduation) My friends and I helped each other with science-related matters and set problems for each other	0.247	0.103	0.006	*0.807*	0.189	0.025	0.058	0.084	-0.071
16. (Junior high to university graduation) I talked with other people about my difficulties in science studies	0.164	0.054	0.03	*0.782*	0.087	-0.105	0.098	0.085	0.173
7. (Elementary school) I studied science together with friends	-0.04	-0.045	0.051	*0.694*	0.249	0.005	0.354	0.188	0.048

8. (Elementary school) I talked with other people about my difficulties in science studies	-0.076	0.022	-0.004	*0.658*	0.155	-0.108	0.388	0.087	0.256
6. (Elementary school) My friends and I helped each other with science-related matters and set problems for each other	-0.018	-0.031	0.115	*0.61*	0.357	0.036	0.384	0.179	0.015
13. (Junior high to university graduation) Added relevant pictures and illustrations to my notes as I studied science	0.371	0.075	-0.053	*0.49*	0.392	0.061	0.165	0.013	-0.052
5. (Elementary school) Added relevant pictures and illustrations to my notes as I studied science	0.057	-0.077	0.036	*0.442*	0.396	0.074	0.473	0.074	0.019
4. (Elementary school) Associated science studies with my day-to-day life	-0.067	0.005	0.167	0.191	*0.771*	0.105	0.26	0.184	-0.059
3. (Elementary school) Associated science studies with my interests and things I know well	-0.062	0.037	0.206	0.079	*0.77*	0.133	0.242	0.161	-0.085
11. (Junior high to university graduation) Associated science studies with my interests and things I know well	0.271	0.264	0.094	0.235	*0.71*	0.11	-0.065	0.101	-0.19
2. (Elementary school) Thought science study would be beneficial to my future	-0.051	0.07	0.191	0.137	*0.684*	0.064	0.326	0.093	0.007
12. (Junior high to university graduation) Associated science studies with my day-to-day life	0.263	0.25	0.026	0.345	*0.679*	0.08	-0.05	0.084	-0.121
10. (Junior high to university graduation) Thought science study would be beneficial to my future	0.288	0.305	0.14	0.19	*0.658*	0.098	-0.062	0.029	-0.137
9. (Junior high to university graduation) I had thought about what I would need if I were to be accepted by a higher school of my choice	0.364	0.149	0.104	0.247	*0.447*	0.072	0.001	-0.013	0.045
4. (Elementary school) I felt comfortable studying science	0.017	0.043	0.381	-0.019	0.078	*0.832*	0.001	0.082	-0.173
3. (Elementary school) I studied science without concern	0.02	0.042	0.382	-0.059	0.075	*0.83*	-0.009	0.098	-0.158
2. (Elementary school) I was able to study science with peace of	0.023	0.061	0.424	-0.003	0.095	*0.786*	0.014	0.077	-0.163

mind									
7. (Junior high to university graduation) I studied science without concern	0.102	0.517	0.019	-0.021	0.074	*0.731*	-0.009	0.052	-0.211
6. (Junior high to university graduation) I was able to study science with peace of mind	0.12	0.545	0.044	0.005	0.081	*0.705*	0.029	0.02	-0.219
8. (Junior high to university graduation) I felt comfortable studying science	0.08	0.575	0.012	0.003	0.054	*0.698*	0.039	0.017	-0.228
9. (Elementary school) Summarized key points of various matters learned, to further understanding	0.246	0.008	0.053	0.179	0.102	0.03	*0.739*	0.337	-0.043
5. (Elementary school) Reorganized notes when studying, for better recall of material learned	0.205	-0.001	0.035	0.184	0.01	-0.001	*0.712*	0.317	0.017
6. (Elementary school) Worked individually on exercises not included in homework	0.194	0.081	0.195	0.152	0.14	-0.037	*0.681*	0.185	-0.04
8. (Elementary school) Recalled and reviewed important matters repeatedly when studying for tests	0.265	-0.012	0.05	0.188	0.069	0.021	*0.64*	0.462	-0.009
10. (Elementary school) Applied material learned earlier when studying new topics	0.149	0.069	0.182	0.086	0.241	0.13	*0.51*	0.442	-0.157
1. (Elementary school) I had thought about what I would need if I were to be accepted by a higher school of my choice	-0.06	0.06	0.091	0.225	0.312	-0.019	*0.471*	-0.035	0.271
2. (Elementary school) When doing homework, I tried to recall what was taught in class, to fully answer problems	0.108	0.018	0.124	0.141	0.074	0.087	0.259	*0.764*	-0.028
4. (Elementary school) Always tried to make sense of what the teacher was saying, even if I did not understand at the time	0.136	-0.011	0.128	0.078	0.101	0.064	0.193	*0.744*	-0.02
1. (Elementary school) Compiled hints from class instruction, books, etc., when studying for tests	0.026	-0.01	0.123	0.08	0.083	0.109	0.212	*0.707*	-0.013
7. (Elementary school) Completed tasks even if the material being studied was boring and uninteresting	0.218	-0.031	0.173	0.078	0.04	0.042	0.347	*0.519*	-0.054

3. (Elementary school) When studying, I would put important but difficult words into my own words	0.053	0.073	0.096	0.166	0.132	-0.004	0.459	*0.51*	0.003
3. (Junior high to university graduation) When studying science, I quickly lost interest	-0.141	-0.381	-0.075	0.026	-0.095	-0.125	-0.007	0.028	*0.792*
4. (Junior high to university graduation) When doing difficult science problems, I often tired quickly and gave up	-0.119	-0.394	-0.049	0.039	-0.075	-0.118	-0.031	0.037	*0.781*
2. (Elementary school) When doing difficult science problems, I often tired quickly and gave up	0	0.008	-0.416	0.033	-0.034	-0.18	-0.055	-0.038	*0.772*
1. (Elementary school) When studying science, I quickly lost interest	-0.003	0.02	-0.423	0.037	-0.05	-0.185	-0.041	-0.056	*0.767*
1. (Elementary school) When studying science, I tended to become anxious	0.061	-0.041	-0.36	0.117	-0.037	-0.31	0.12	-0.083	*0.528*
5. (Junior high to university graduation) When studying science, I tended to become anxious	0.104	-0.368	0.094	0.085	-0.027	-0.252	0.074	-0.047	*0.509*

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